Second UK-Latin America Workshop on DAQ and Data Selection

Photon-Detector simulations

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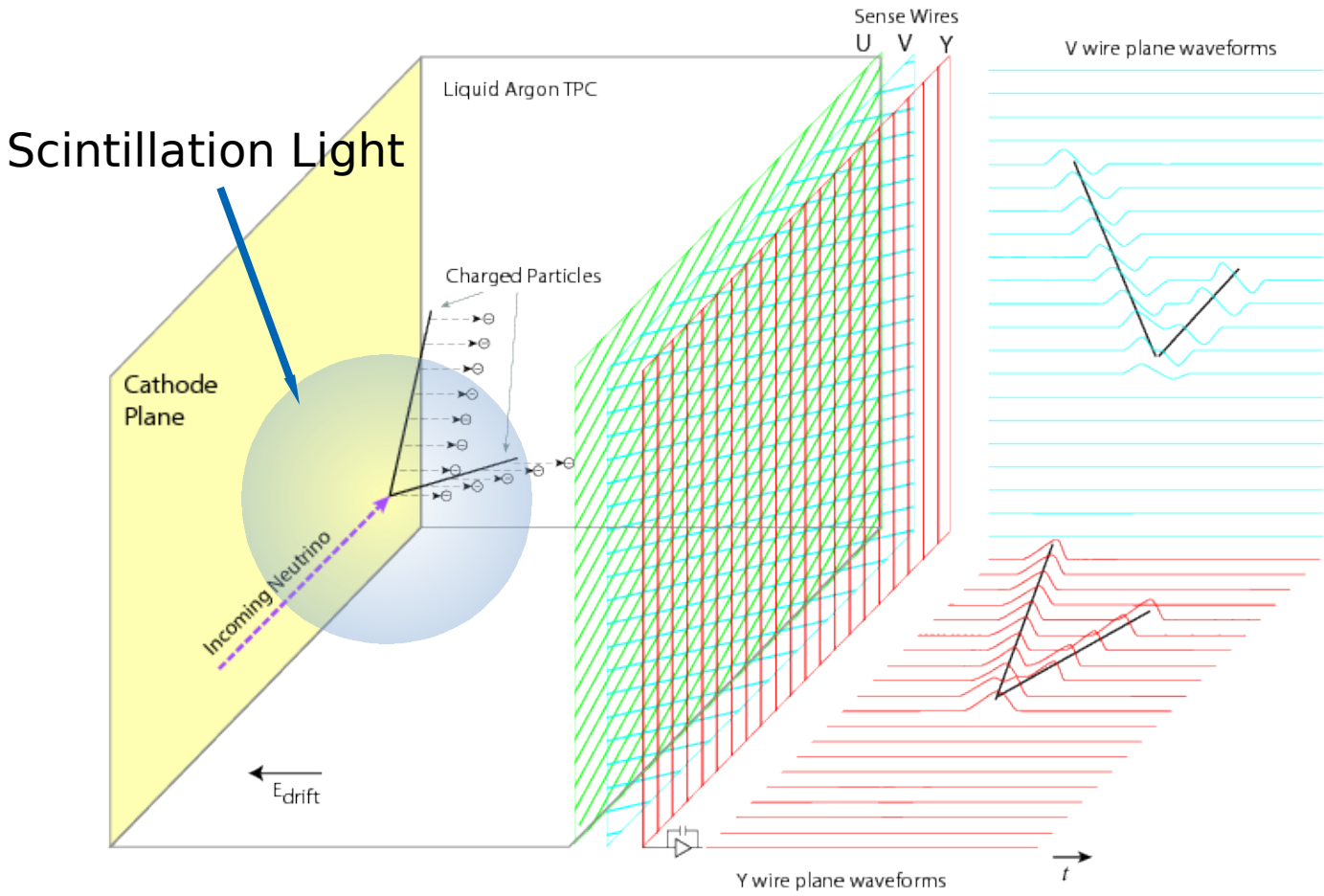
Outline

- **DUNE LarTPC Overview**
- **Photon Detector Simulation**
  - LArSoft PD simulation chain
  - SSP Leading Edge Discriminator
  - Some results
- **Getting Help**
- **Working Groups**

DUNE LArTPC Overview

- Track information: LAr ionization
- Trigger for SNB, proton decay and T0: photons of LAr scintillation

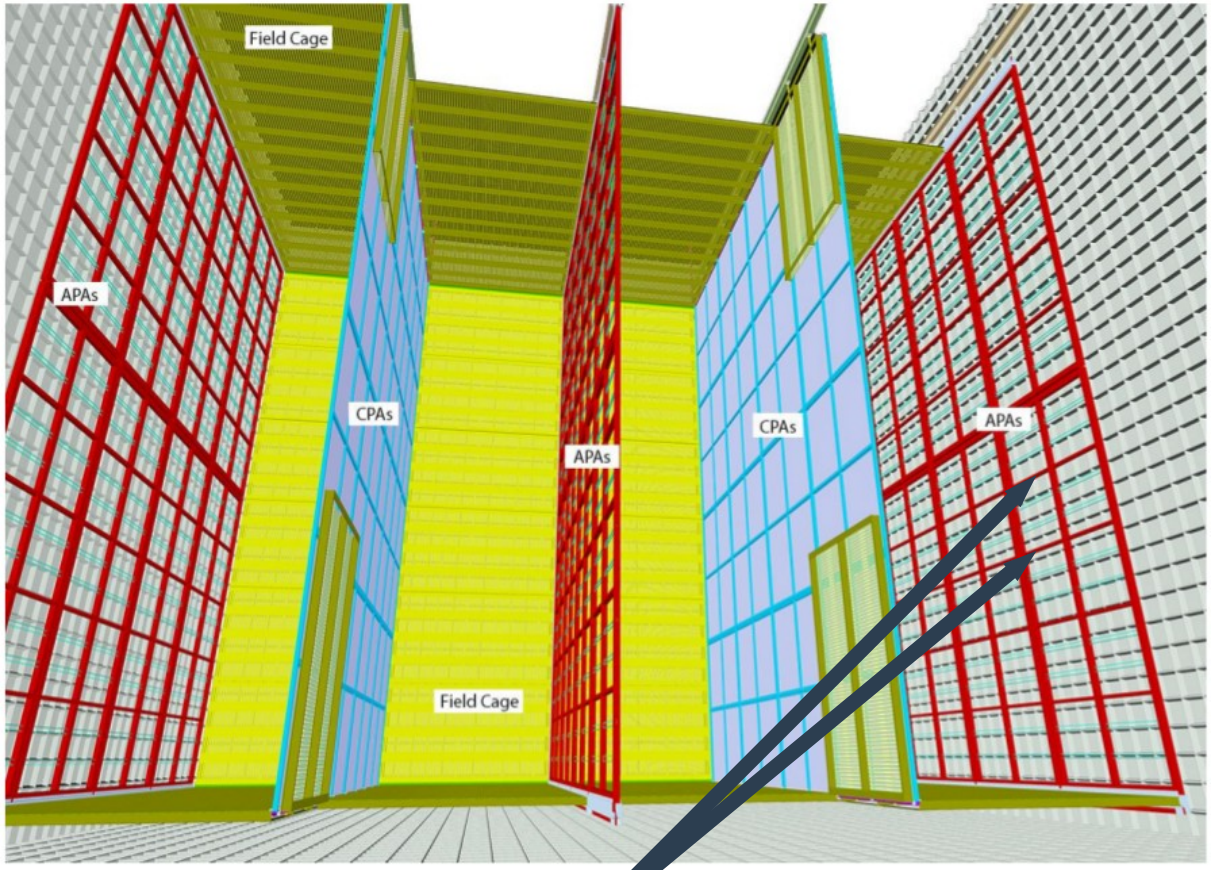


Y. Li et al., Measurement of Longitudinal Electron Diffusion in Liquid Argon, Nucl. Inst. Meth. A 816 (2016) pp. 160–170, arXiv:1508.07059 [hep-ex].

DUNE LArTPC Overview

DUNE SP 10kt modules:

- 150 APAs (anode plane assembly) per module;
- 10 Photon Detectors (PD) modules per APA;
- 4 optical channels per PD;
- Total: 6000 PD channels.



PD Simulation

LArSoft PD simulation chain

1st step: light production and transport

- 24,000 γ/MeV in LAr: prohibitive GEANT4 simulations;
- Are created photon maps (photons on photo-sensors), stored on a photon library;

PD Simulation

LArSoft PD simulation chain

2nd step: electronic response

- SiPM signal processor (SSP) readout electronics;
- Waveforms are produced on each channel for each true photon, considering dark noise, crosstalk and afterpulsing;
- The SSP self-triggering algorithm (**Leading Edge Discriminator**) determine if and when the waveform will be read out and stored;

PD Simulation

LArSoft PD simulation chain

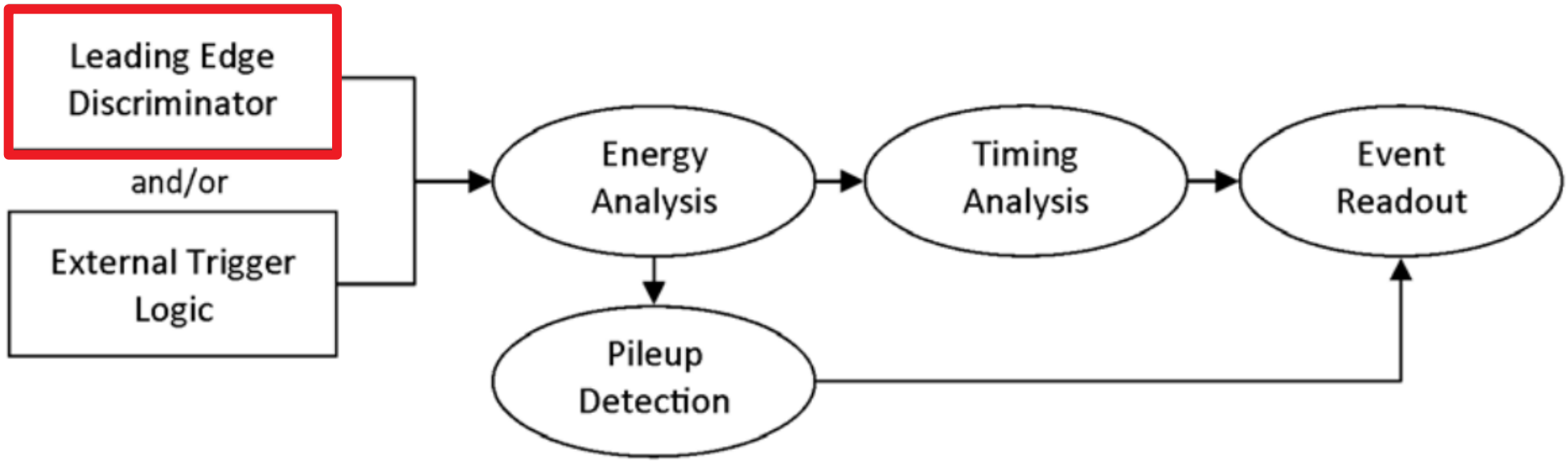
3rd step: reconstruction (3 stages)

- “Hit finding”: first peak and total amount of light channel-by-channel;
- “Flash finding”: searches for coincident hits across multiple channels, recording the flash time, amount of light, and APA y-z position;
- “Flash match”: matches the flash to the original event.

PD Simulation

SSP Leading Edge Discriminator

- First element of the SSP triggering system
- Selects the waveforms for non-beam events (SNB, Proton decay ...)

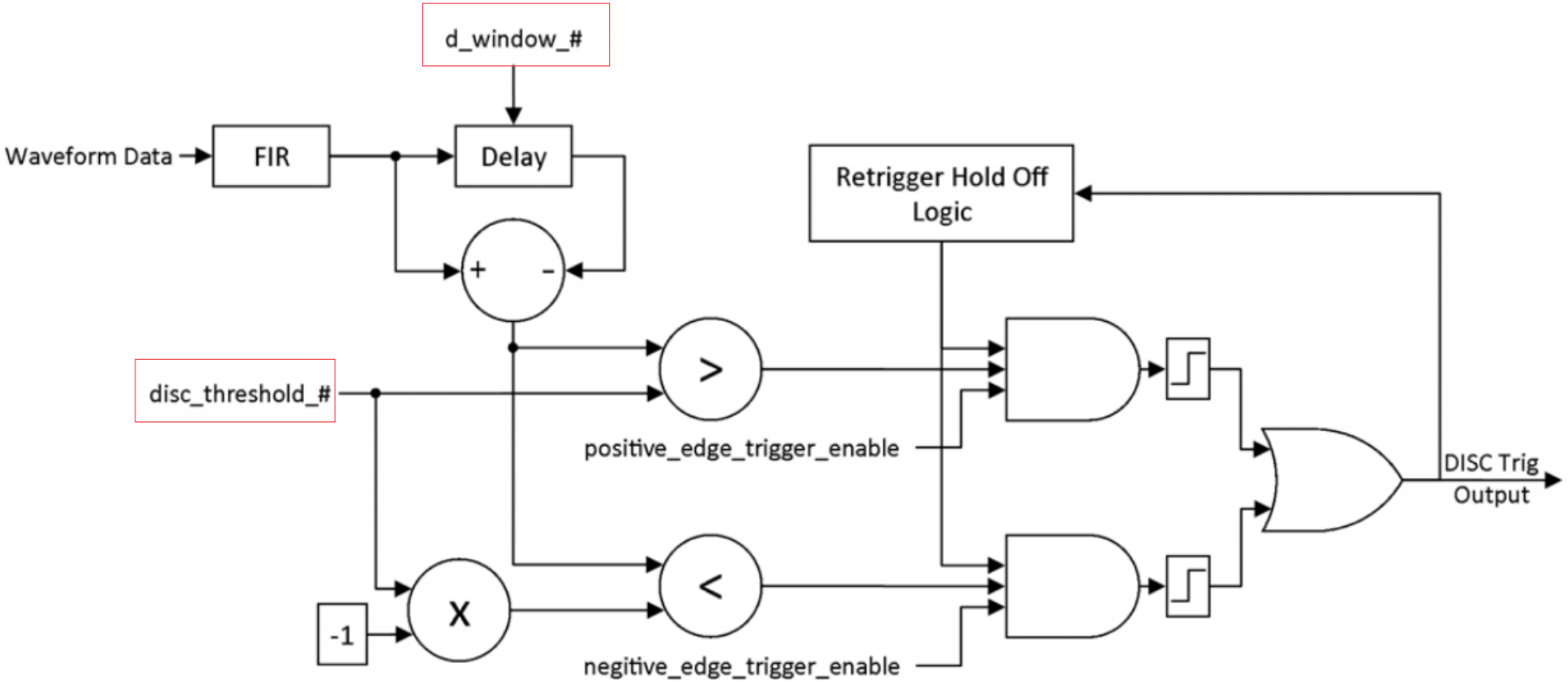


SiPM Signal Processor User Manual
https://indico.fnal.gov/event/12392/contribution/1/material/7/0.pdf

PD Simulation

SSP Leading Edge Discriminator

How it works



SiPM Signal Processor User Manual

PD Simulation

SSP Leading Edge Discriminator

Implementation process

1. Extraction of LArSoft simulated waveforms (fhicl file configuration)

```
...
physics:
{
   producers:
   {
      opdigi:    @local::dunefd_opdigi_threegang  #simple digitizer
      rns:       { module_type: "RandomNumberSaver" }
   }
   analyzers:
   {
      opdigiana:   @local::dunefd_opdigiana #prebuilt analyzer module, providing waveforms
   }

   simulate: [
                  opdigi,
                  rns
             ]
   analyzeIt:  [
                  opdigiana
               ]
...
}
```

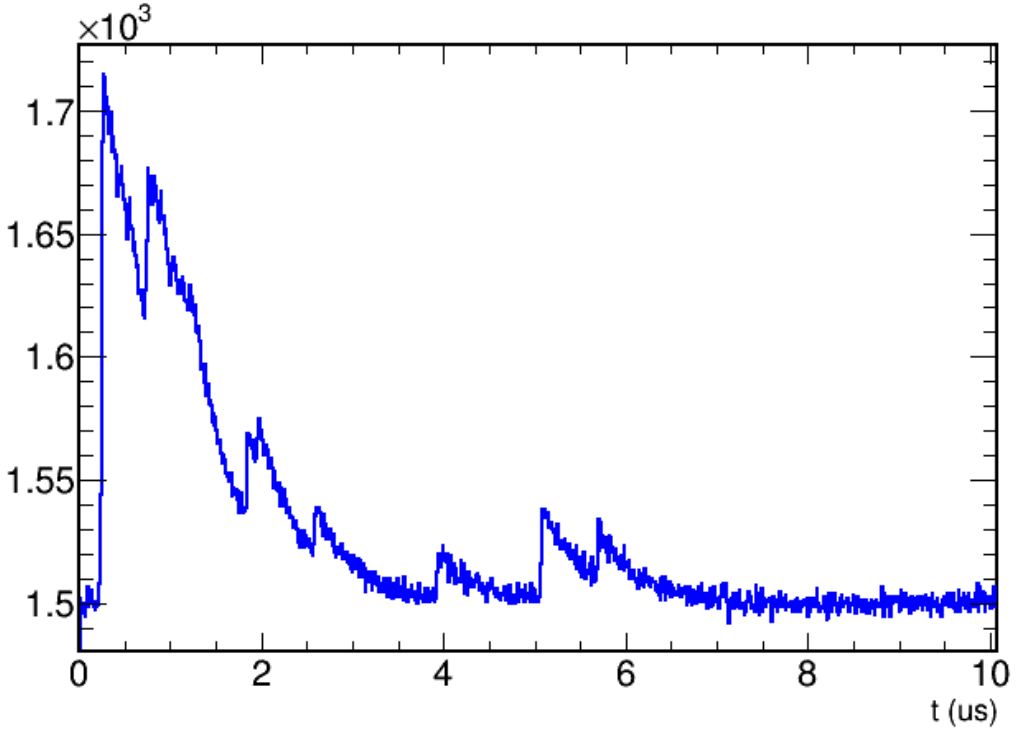
PD Simulation

SSP Leading Edge Discriminator

Implementation process

1. Extraction of LArSoft simulated waveforms (fhicl file configuration)

Will add a folder (opdigiana) with TH1D histograms for each waveform



PD Simulation

SSP Leading Edge Discriminator

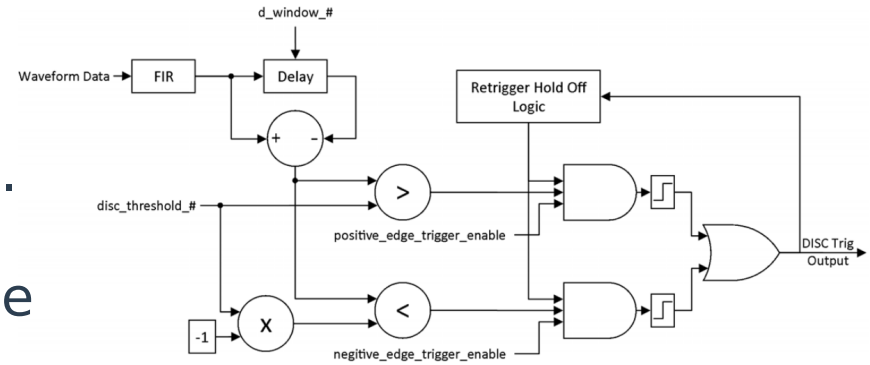
Implementation process

2. Create your own program

- LArSoft could be complicated for beginners (like me when started)

- Write your own programs (good idea).

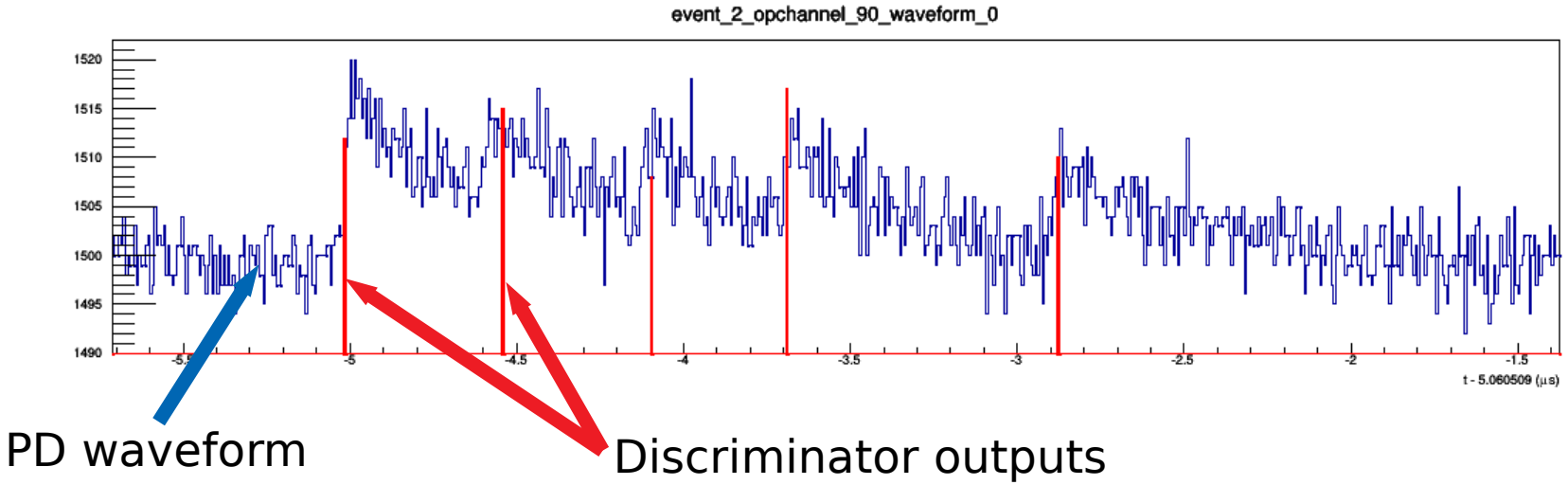
Using a ROOT macro, I implemented the discriminator, providing the step 1 waveforms and obtaining trigger output signals, considering the discriminator threshold and delay window.



PD Simulation

SSP Leading Edge Discriminator

3. Verify your work



PD Simulation

SSP Leading Edge Discriminator

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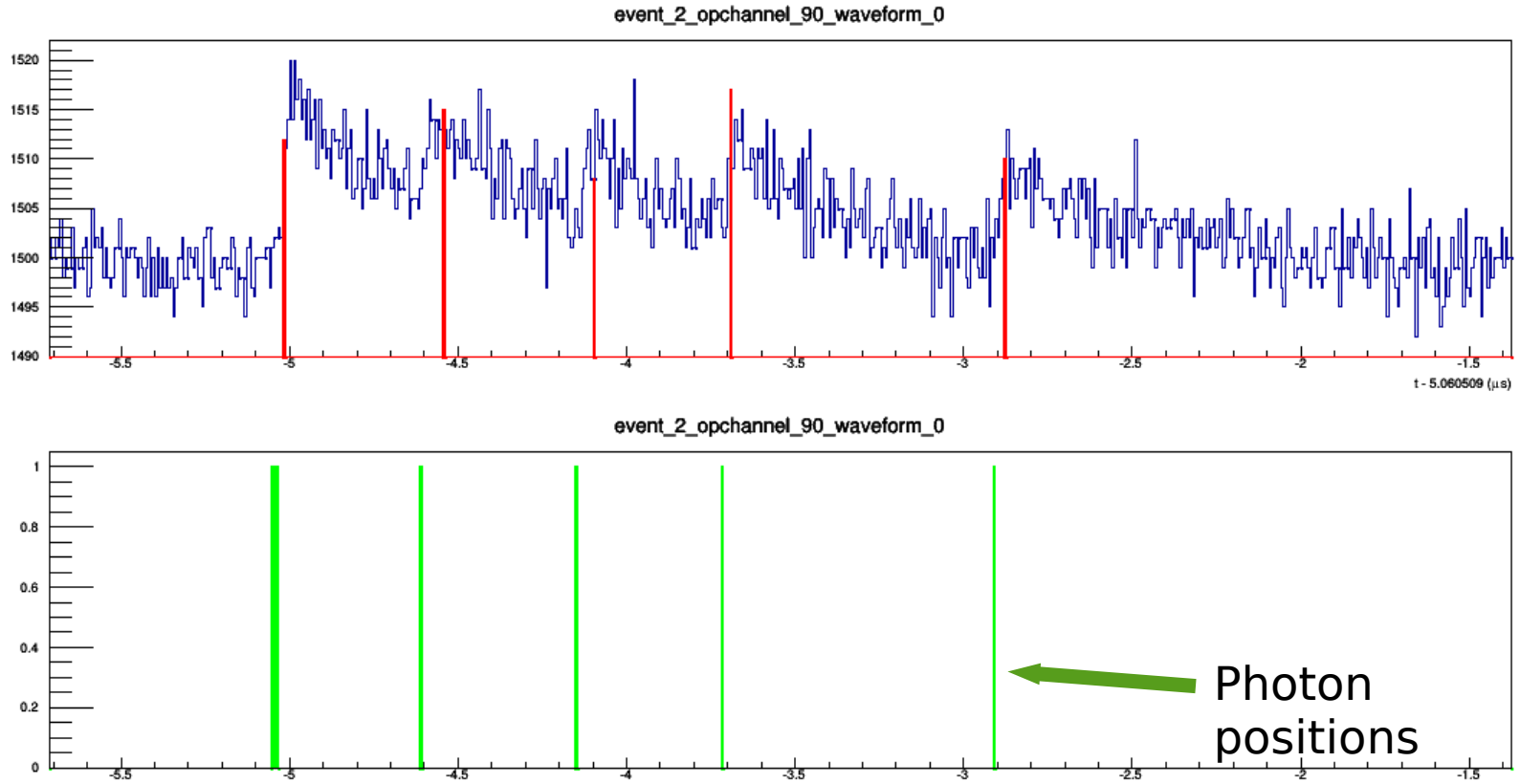


PD Simulation

SSP Leading Edge Discriminator

Implementation process

4. LArSoft implementation

- Create a new module:
  - Could take some time and a lot of work

- Modify an existent module:
  - SSP Leading Edge algorithm
    `.../dunetpc/dune/OpticalDetector/AlgoSSPLeadingEdge.cc`
  - Called inside the Digitizer module
    `.../dunetpc/dune/OpticalDetector/OpDetDigitizerDUNE_module.cc`
  - With fhicl parameters in
    `.../dunetpc/dune/OpticalDetector/sspmodules.fcl`

PD Simulation

SSP Leading Edge Discriminator

Implementation process

4. LArSoft implementation

sspmodules.fcl

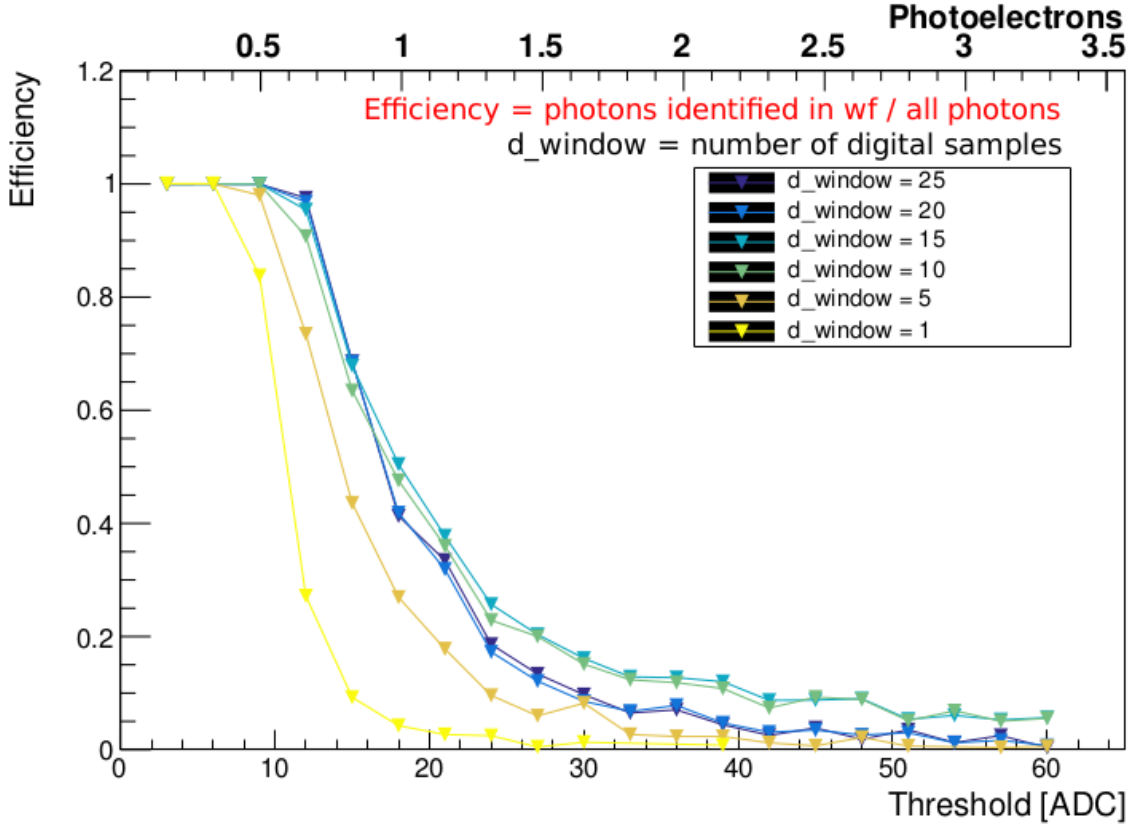
```
...

standard_algo_sspleadingedge:

{

    Name:         "SSP_LED"
    ADCThreshold:       10
   #MinWidth:           10
   #SecondThreshold:    1
    Pedestal:         1500
    DWindow:            10
    ReadoutWd:         700
    PreTrg:             20

}
...
```

PD Simulation

SSP Leading Edge Discriminator

Some results

Photon selection efficiency for different discriminator parameters



PD Simulation

SSP Leading Edge Discriminator

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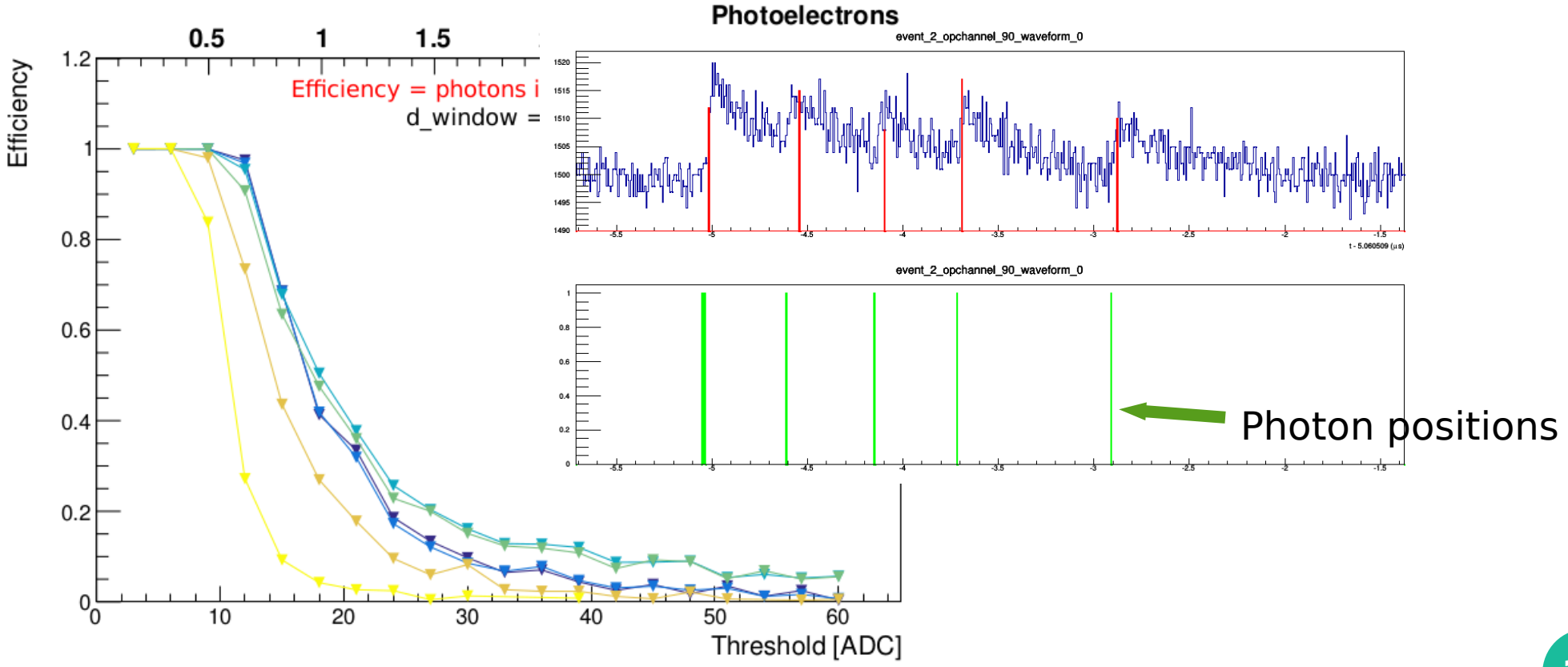
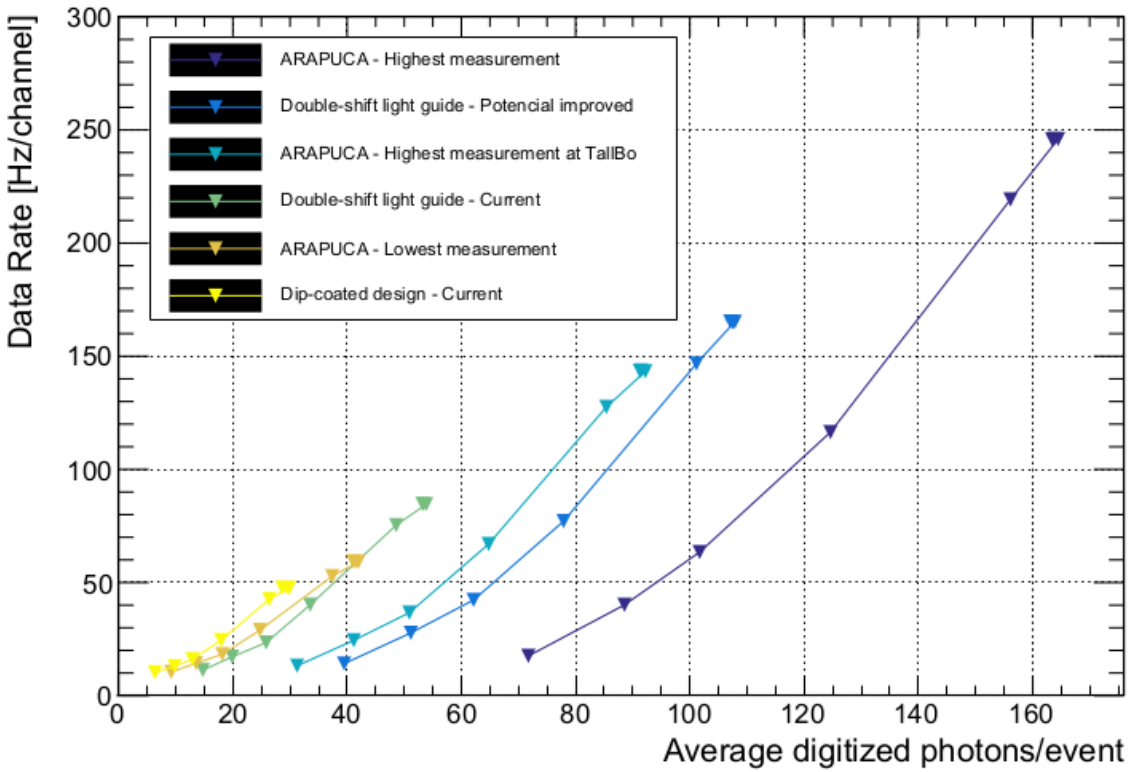


PD Simulation

SSP Leading Edge Discriminator

Some results

Data Rate per optical channel for different photon collector



Getting Help

Don’t hesitate in ask for help. There are some channels and a lot of people ready to help

- Tutorials:
  https://cdcvs.fnal.gov/redmine/projects/dunetpc/wiki
- Doxygen (codes):
  http://internal.dunescience.org/doxygen/index.html
- Slack (very active):
  https://dunescience.slack.com
  - pd-sim-reco
  - larsoft
  - larsoft_beginners

Working Groups

If you’re interest in start to work in PD sim topics,

- **Working groups (regular meetings):**
  - Far Detector Simulation & Reconstruction:
    - Alex Himmel, Christopher Backhouse, Tingjun Yang
  - Photon Detector Simulation & Physics:
    - Alex Himmel, Andrzej Szelc, Kate Scholberg

Questions?